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ENHANCING DAM SAFETY ANALYSIS THROUGH NEUTROSOPHIC THERMAL ANALYSIS

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Abstract

From engineering perspective, conducting thermal analysis on dams is crucial for devising safety strategies to mitigate cracking.

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Traditionally, a variety of statistical methods have been utilized for examining dam temperatures. However, in this work, we have employed neutrosophic methods to carry out the thermal analysis. Neutrosophic statistics, which rely on interval data, extend the scope of interval analysis. We utilized temperature data spanning 24 hours, 7 days, 15 days, and one month for our analysis. This study integrates both conventional and neutrosophic methods to analyze the gathered temperature data, subsequently generating comparative graphs. Upon reviewing these graphs, it became apparent that the neutrosophic method surpassed the traditional approach in terms of reliability and effectiveness. Consequently, it can be concluded that the neutrosophic method offers a more informative, accurate, and reliable basis for decision-making in the context of dam safety analysis.

1. Introduction

When building a dam structure, large quantities of concrete are utilized in order to construct a monolithic mass structure. The hydration process of cement produces heat in the dam, causing a high temperature within the dam structure. Because of its massiveness, the dam requires many years to reach a stable temperature after its peak temperature. As a result of changes in the temperature of concrete dams, cracks are typically created, which creates problems in the safety and normal operation of the dam. Therefore, thermal analysis is required to minimize the occurrence of cracks in the dams caused by temperature changes to prevent such problems (Husein Malkawi et al. [11]). The hydration of cement and the mass of the cement in the dam body is accompanied by a rise in temperature. Dams maintain a steady temperature after peak temperatures have been reached, which is usually completed over several years, and such a process makes dams stay intact (Zhou et al. [21]). A variety of techniques are employed during the hydration phase for evaluating the thermal analysis of concrete structures. These techniques range from manual calculations to three-dimensional modeling. Three-dimensional analysis techniques are more complex and difficult than manual computation techniques. The finite element method has been employed in recent years as a tool for studying the behavior of mass concrete structures such as dams. The temperature distribution in concrete dams of a given size was modeled using a finite element method (Zhou et al. [21]). A better understanding of dam gallery cracking and constructing a dam with the right structural design is also important for dam safety (Lin et al. [13]). The causes of cracking in the dam crest were studied by different researchers based on the measurement of long-term data (Adamo et al. [1]). A 3D finite element model was used to investigate temperature evolution within under-construction dam structures to examine cracking, thermal stress, and crack growth (Afzal et al. [3]).

Several researchers have explored the mechanism behind typical temperature cracking and the effects of various heating control strategies on avoiding these cracks. A clear understanding of the actual temperature distribution within concrete dams is crucial for successfully managing the temperature and preventing fractures (Noorzaei et al. [15]). Several complex technical challenges are associated with the construction of such giant dams. Because of absorption heat, challenging surrounding environments, cooling conditions, and strong foundation constraints, temperature and fracture controlling are the most significant technical challenges when designing and constructing mass concrete structures (Castilho et al. [7]). There are several anti-cracking methods developed over many years of experience and study, but if the true temperature variation of the materials cannot be determined in a timely manner, good temperature management cannot be implemented. In the modern world, it is becoming more and more apparent that there is a need to regulate the monitoring system of concrete dams as they become a concern for the nation, using the constants and inconsistencies associated with large hydropower dams (Sherard [18]). Temperature has a critical influence on the kinematics and ductility of concrete dams; because of this, careful consideration of natural weather patterns is explicable in concrete dams, as these patterns may influence thermal heating, which can cause high loads to be placed on concrete dam walls, and may significantly impact fracture formation and conduct (Chen et al. [8]). These structures of composite dams may also experience increased temperatures due to deflections and universal climate variations (Afzal et al. [4]). As the temperature plays a significant role in the permanent reinforcement of concrete dams, considering the suitable boundary conditions is a significant factor, particularly in the thermal analysis related to nonlinear fluxes of heat through the solid (Afzal et al. [2]). For dam design, the FEM is used to determine periodic temperatures and stress patterns in concrete (Zhou et al. [20]). This method has significantly improved the understanding of the heating characteristics of concrete dams during the dam system's initial design, control and management phase. Research has recently explored: "Stress Analysis of Concrete Structures" influenced by parameters of thermal stress, determinants of the fairly frequent temperature distribution in concrete dams, and the durability of the regular interval heat flux (Daoud et al. [9]). Environmental exposure was investigated by analyzing thermal stress of a concrete dam that features an arch concrete structure (Fluixá-Sanmartín et al. [10]). In other studies, advanced computational methods were developed, such as the framework for investigating concrete dams with regard to thermal effects linked to ecology, a time-displacement model of hydrostatic pressure and temperature, and data observing concrete dams based on hydrostatic pressure cyclical states (Léger and Leclerc [12]). Several other authors have examined the sensitivity of thermal fields in gigantic structures as well as the consideration of temperature directives when building concrete dams in arctic regions. The temperature behavior of concrete dams has been extensively examined in contemporary times, taking into consideration the effects of implementing environmental parameters on temperature behavior (Léger and Leclerc [12]).

In this study, we applied neutrosophic methods for thermal analysis of dams. Usually, it has been observed that there are various statistical methods applied to analyze dam temperature (Mata et al. [14]). For accurate data of dam temperature over the years, it has been come into notice that many researcher use graphs and classical formulas. Such kind of analysis not only provides accurate information, but it also provides a single value in a specific time (Perner and Obernhuber [17]). Whereas in case of interval data analysis, it would not provide accurate information, if it has been analyzed through all classical methods (Afzal et al. [5]). In this regard, the intervals data can be analyzed by using neutrosophic statistical method. The neutrosophic statistical method has been introduced by Smarandache [19]. The neutrosophic method has become more popular among researchers to analyze the various data problems (Aslam et al. [6]). The neutrosophic method has been applied to analyze the variance in data under indeterminacy interval, on the other hand, the fix point values have been analyzed through classical method. The classical method has failed to explain variance in data under various indeterminacy intervals.

The neutrosophic probability distribution may represent through three curves (Patro and Smarandache [16]). First, it may represent the chance of occurrence of events. Second, it may represent the chance of nonoccurrence of events. Third, the neutrosophic probability distribution may represent indeterminate chances for occurrence of events.

2. Modeling of Neutrosophic Approach

In this study, we applied neutrosophic methods for interval based thermal analysis of dams. Keeping in view the fix point values deal with classical method and using average formula, all intervals of dam body temperature have to be converted into fixed point values. Let $T_{Ni} \in [T_{Li}, T_{Ui}]$. Then the classical formula can be written as:

$$T_{Ni} = \left(\frac{T_{Li} + T_{Ui}}{2}\right), \quad i = 1, 2, 3, 4, \ldots, n_N. \tag{1}$$

For the neutrosophic method, first, we develop a formula for the dam temperature analysis. Let $T(\%BT)_N$ be a neutrosophic variable for temperature with $T(\%BT)_N \in [T(\%BT)_L, T(\%BT)_U]$ a measured interval of dam temperature at specific time in %BT. Here $T(\%BT)_L$ and $T(\%BT)_U$ are, respectively, the lower and upper measurements of the interval. Therefore, neutrosophic formula for dam temperature with indeterminacy $i_N \in [i_L, i_U]$ can be written as:

$$T(\%BT)_N = T(\%BT)_L + T(\%BT)_U i_N; \quad i_N \in [i_L, i_U]. \tag{2}$$

Equation (2) is an extension of equation (1). The equation consists of two parts, $T(\%BT)_L$ and $T(\%BT)_U i_N$, determined and indeterminate, respectively, and $i_N \in [i_L, i_U]$, indeterminacy interval. To use neutrosophic approach $i_L = 0$, we can obtain i_U by using $T(\%BT)_U - T(\%BT)_L / T(\%BT)_U$.

3. Integration for Computational Algorithm

Following is the comparison of computational algorithms by classical and neutrosophic approach:

	Classical approach		**Neutrosophic approach**
Step 1	Starting outer loop $i = 1$ to $i <= n_N$	**Step 1**	Start outer loop from $i = 1$ to $i <= n_N$
Step 2	Formula execution: $T_{Ni} = \left(\frac{T_{Li} + T_{Ui}}{2}\right)$	**Step 2**	Formula execution $i_U = \left(\frac{T(\%BT)_U - T(\%BT)_L}{T(\%BT)_U}\right)$
Step 3	Output, calculation of each interval and graphical representation	**Step 3**	Nested loop $j_L = 0$ to $j_L <= i_U$
Step 4	Nested loop $j = 0$ to $j <= n_N$	**Step 4**	Calculate $T(\%BT)_N = T(\%BT)_L + T(\%BT)_U i_N;$ $i_N \in [i_L, i_U]$
Step 5	Incremental operator and go to next index	**Step 5**	Inner loop completion
Step 6	Inner loop completion	**Step 6**	Incremental operator and go to next index
Step 7	Outer loop completion	**Step 7**	Outer loop completion

4. Data Collection

The data is collected from a dam situated on Kunhar River in Pakistan. The 1-day, 7-day, 15-day, and 30-day temperatures were measured from the dam site to complete this study.

Table 1. Measurement of temperature °C

Point No	A	B	C	D	E
V-1	16.47	21.03	23.8	22.8	23.26
V-2	16.21	20.41	23.6	23.12	23.28
V-3	16.5	20.57	23.7	22.75	23.66
V-4	16.03	20.58	24.11	23.53	24.03
V-5	15.12	20.6	24.27	23.62	23.32
V-6	14.74	20.71	24.18	23.71	23.76
V-7	14.5	20.58	23.64	23.59	23.27
V-8	15	20.21	23.77	22.78	22.93
V-9	14.61	20.7	23.37	22.93	23.6
V-10	15.5	20.91	23.5	23.07	23.97
V-11	15.62	20.61	23.67	23.35	23.83
V-12	15.67	20.73	23.52	23.55	23.49
V-13	15.51	21.23	23.82	23.31	23.71
V-14	15.97	21.2	23.66	22.75	23.71
V-15	15.5	21.11	23.51	23.01	23.85

Table 1 represents the data collected from fifteen different locations named at point number. A is the initial reading of temperature, B is the temperature reading at 1-day, C is the temperature at 7-day, D is the temperature at 15-day and E is the temperature at 30 days.

5. Thermal Analysis of Temperature Data

Keeping in view the data collected from the dam site, as mentioned in Table 1, the following are the classical and neutrosophic analyses of data. Table 2 represents the classical data analysis of dam temperature whereas Tables 3-6 provide the interval-wise neutrosophic analysis, and Table 7 reflects the integrated neutrosophic analysis of all the defined intervals.

Table 2. Classical analysis of data

Sr. #	**A**	**B**	**C**	**D**
01	18.75	20.135	19.635	19.865
02	18.31	19.905	19.665	19.745
03	18.535	20.1	19.625	20.08
04	18.305	20.07	19.78	20.03
05	17.86	19.695	19.37	19.22
06	17.725	19.46	19.225	19.25
07	17.54	19.07	19.045	18.885
08	17.605	19.385	18.89	18.965
09	17.655	18.99	18.77	19.105
10	18.205	19.5	19.285	19.735
11	18.115	19.645	19.485	19.725
12	18.2	19.595	19.61	19.58
13	18.37	19.665	19.41	19.61
14	18.585	19.815	19.36	19.84
15	18.305	19.505	19.255	19.675

Table 3. Neutrosophic analysis of 1-day temperature

Point No	**Interval**	**Modeling**
V-1	[16.47, 21.03]	$16.47 + 21.03\ I_T;\ \ I_T \in [0, 0.216]$
V-2	[16.21, 20.41]	$16.21 + 20.41\ I_T;\ \ I_T \in [0, 0.205]$
V-3	[16.50, 20.57]	$16.50 + 20.57\ I_T;\ \ I_T \in [0, 0.197]$
V-4	[16.03, 20.58]	$16.03 + 20.58\ I_T;\ \ I_T \in [0, 0.221]$
V-5	[15.12, 20.60]	$15.12 + 20.60\ I_T;\ \ I_T \in [0, 0.266]$
V-6	[14.74, 20.71]	$14.74 + 20.71\ I_T;\ \ I_T \in [0, 0.288]$
V-7	[14.50, 20.58]	$14.50 + 20.58\ I_T;\ \ I_T \in [0, 0.295]$
V-8	[15.00, 20.21]	$15.00 + 20.21\ I_T;\ \ I_T \in [0, 0.257]$
V-9	[14.61, 20.70]	$14.61 + 20.70\ I_T;\ \ I_T \in [0, 0.294]$
V-10	[15.50, 20.91]	$15.50 + 20.91\ I_T;\ \ I_T \in [0, 0.258]$
V-11	[15.62, 20.61]	$15.62 + 20.61\ I_T;\ \ I_T \in [0, 0.242]$
V-12	[15.67, 20.73]	$15.67 + 20.73\ I_T;\ \ I_T \in [0, 0.244]$
V-13	[15.51, 21.23]	$15.51 + 21.23\ I_T;\ \ I_T \in [0, 0.269]$
V-14	[15.97, 21.20]	$15.97 + 21.20\ I_T;\ \ I_T \in [0, 0.246]$
V-15	[15.50, 21.11]	$15.50 + 21.11\ I_T;\ \ I_T \in [0, 0.265]$

Table 4. Neutrosophic analysis of 7-day temperature

Point No	**Interval**	**Modeling**
V-1	[16.47, 23.80]	$16.47 + 23.80\ I_T;\ \ I_T \in [0, 0.307]$
V-2	[16.21, 23.60]	$16.21 + 23.60\ I_T;\ \ I_T \in [0, 0.313]$
V-3	[16.50, 23.70]	$16.50 + 23.70\ I_T;\ \ I_T \in [0, 0.303]$
V-4	[16.03, 24.11]	$16.03 + 24.11\ I_T;\ \ I_T \in [0, 0.335]$
V-5	[15.12, 24.27]	$15.12 + 24.27\ I_T;\ \ I_T \in [0, 0.377]$
V-6	[14.74, 24.18]	$14.74 + 24.18\ I_T;\ \ I_T \in [0, 0.390]$
V-7	[14.50, 23.64]	$14.50 + 23.64\ I_T;\ \ I_T \in [0, 0.386]$
V-8	[15.00, 23.77]	$15.00 + 23.77\ I_T;\ \ I_T \in [0, 0.368]$
V-9	[14.61, 23.37]	$14.61 + 23.37\ I_T;\ \ I_T \in [0, 0.374]$
V-10	[15.50, 23.50]	$15.50 + 23.50\ I_T;\ \ I_T \in [0, 0.340]$
V-11	[15.62, 23.67]	$15.62 + 23.67\ I_T;\ \ I_T \in [0, 0.340]$
V-12	[15.67, 23.52]	$15.67 + 23.52\ I_T;\ \ I_T \in [0, 0.333]$
V-13	[15,51, 23.82]	$15.51 + 23.82\ I_T;\ \ I_T \in [0, 0.348]$
V-14	[15.97, 23.66]	$15.97 + 23.66\ I_T;\ \ I_T \in [0, 0.325]$
V-15	[15.50, 23.51]	$15.50 + 23.51\ I_T;\ \ I_T \in [0, 0.340]$

Table 5. Neutrosophic analysis of 15-day temperature

Point No	**Interval**	**Modeling**
V-1	[16.47, 22.80]	$16.47 + 22.80\ I_T;\ \ I_T \in [0, 0.277]$
V-2	[16.21, 23.12]	$16.21 + 23.12\ I_T;\ \ I_T \in [0, 0.298]$
V-3	[16.50, 22.75]	$16.50 + 22.75\ I_T;\ \ I_T \in [0, 0.274]$
V-4	[16.03, 23.53]	$16.03 + 23.53\ I_T;\ \ I_T \in [0, 0.318]$
V-5	[15.12, 23.62]	$15.12 + 23.62\ I_T;\ \ I_T \in [0, 0.359]$
V-6	[14.74, 23.71]	$14.74 + 23.71\ I_T;\ \ I_T \in [0, 0.378]$
V-7	[14.50, 23.59]	$14.50 + 23.59\ I_T;\ \ I_T \in [0, 0.385]$
V-8	[15.00, 22.78]	$15.00 + 22.78\ I_T;\ \ I_T \in [0, 0.341]$
V-9	[14.61, 22.93]	$14.61 + 22.93\ I_T;\ \ I_T \in [0, 0.362]$

V-10	[15.50, 23.07]	$15.50 + 23.07\ I_T;\ I_T \in [0, 0.328]$
V-11	[15.62, 23.35]	$15.62 + 23.35\ I_T;\ I_T \in [0, 0.331]$
V-12	[15.67, 23.55]	$15.67 + 23.55\ I_T;\ I_T \in [0, 0.334]$
V-13	[15.51, 23.31]	$15.51 + 23.31\ I_T;\ I_T \in [0, 0.334]$
V-14	[15.97, 22.75]	$15.97 + 22.75\ I_T;\ I_T \in [0, 0.298]$
V-15	[15.50, 23.01]	$15.50 + 23.01\ I_T;\ I_T \in [0, 0.326]$

Table 6. Neutrosophic analysis of 30-day temperature

Point No	Interval	Modeling
V-1	[16.47, 23.26]	$16.47 + 22.80\ I_T;\ I_T \in [0, 0.291]$
V-2	[16.21, 23.28]	$16.21 + 23.28\ I_T;\ I_T \in [0, 0.303]$
V-3	[16.50, 23.66]	$16.50 + 23.66\ I_T;\ I_T \in [0, 0.302]$
V-4	[16.03, 24.03]	$16.03 + 24.03\ I_T;\ I_T \in [0, 0.332]$
V-5	[15.12, 23.32]	$15.12 + 23.32\ I_T;\ I_T \in [0, 0.351]$
V-6	[14.74, 23.76]	$14.74 + 23.76\ I_T;\ I_T \in [0, 0.379]$
V-7	[14.50, 23.27]	$14.50 + 23.27\ I_T;\ I_T \in [0, 0.376]$
V-8	[15.00, 22.93]	$15.00 + 22.93\ I_T;\ I_T \in [0, 0.345]$
V-9	[14.61, 23.60]	$14.61 + 23.60\ I_T;\ I_T \in [0, 0.380]$
V-10	[15.50, 23.97]	$15.50 + 23.97\ I_T;\ I_T \in [0, 0.353]$
V-11	[15.62, 23.83]	$15.62 + 23.83\ I_T;\ I_T \in [0, 0.344]$
V-12	[15.67, 23.49]	$15.67 + 23.49\ I_T;\ I_T \in [0, 0.332]$
V-13	[15.51, 23.71]	$15.51 + 23.71\ I_T;\ I_T \in [0, 0.345]$
V-14	[15.97, 23.71]	$15.97 + 23.71\ I_T;\ I_T \in [0, 0.326]$
V-15	[15.50, 23.85]	$15.50 + 23.85\ I_T;\ I_T \in [0, 0.350]$

Table 7. Integrated results of neutrosophic analysis for all intervals

Sr. #	**A**	**B**	**C**	**D**
01	$16.47 + 21.03 I_T$; $I_T \in [0, 0.216]$	$16.47 + 23.80 I_T$; $I_T \in [0, 0.307]$	$16.47 + 22.80 I_T$; $I_T \in [0, 0.277]$	$16.47 + 22.80 I_T$; $I_T \in [0, 0.291]$
02	$16.21 + 20.41 I_T$; $I_T \in [0, 0.205]$	$16.21 + 23.60 I_T$; $I_T \in [0, 0.313]$	$16.21 + 23.12 I_T$; $I_T \in [0, 0.298]$	$16.21 + 23.28 I_T$; $I_T \in [0, 0.303]$
03	$16.50 + 20.57 I_T$; $I_T \in [0, 0.197]$	$16.50 + 23.70 I_T$; $I_T \in [0, 0.303]$	$16.50 + 22.75 I_T$; $I_T \in [0, 0.274]$	$16.50 + 23.66 I_T$; $I_T \in [0, 0.302]$
04	$16.03 + 20.58 I_T$; $I_T \in [0, 0.221]$	$16.03 + 24.11 I_T$; $I_T \in [0, 0.335]$	$16.03 + 23.53 I_T$; $I_T \in [0, 0.318]$	$16.03 + 24.03 I_T$; $I_T \in [0, 0.332]$
05	$15.12 + 20.60 I_T$; $I_T \in [0, 0.266]$	$15.12 + 24.27 I_T$; $I_T \in [0, 0.377]$	$15.12 + 23.62 I_T$; $I_T \in [0, 0.359]$	$15.12 + 23.32 I_T$; $I_T \in [0, 0.351]$
06	$14.74 + 20.71 I_T$; $I_T \in [0, 0.288]$	$14.74 + 24.18 I_T$; $I_T \in [0, 0.390]$	$14.74 + 23.71 I_T$; $I_T \in [0, 0.378]$	$14.74 + 23.76 I_T$; $I_T \in [0, 0.379]$
07	$14.50 + 20.58 I_T$; $I_T \in [0, 0.295]$	$14.50 + 23.64 I_T$; $I_T \in [0, 0.386]$	$14.50 + 23.59 I_T$; $I_T \in [0, 0.385]$	$14.50 + 23.27 I_T$; $I_T \in [0, 0.376]$
08	$15.00 + 20.21 I_T$; $I_T \in [0, 0.257]$	$15.00 + 23.77 I_T$; $I_T \in [0, 0.368]$	$15.00 + 22.78 I_T$; $I_T \in [0, 0.341]$	$15.00 + 22.93 I_T$; $I_T \in [0, 0.345]$
09	$14.61 + 20.70 I_T$; $I_T \in [0, 0.294]$	$14.61 + 23.37 I_T$; $I_T \in [0, 0.374]$	$14.61 + 22.93 I_T$; $I_T \in [0, 0.362]$	$14.61 + 23.60 I_T$; $I_T \in [0, 0.380]$
10	$15.50 + 20.91 I_T$; $I_T \in [0, 0.258]$	$15.50 + 23.50 I_T$; $I_T \in [0, 0.340]$	$15.50 + 23.07 I_T$; $I_T \in [0, 0.328]$	$15.50 + 23.97 I_T$; $I_T \in [0, 0.353]$
11	$15.62 + 20.61 I_T$; $I_T \in [0, 0.242]$	$15.62 + 23.67 I_T$; $I_T \in [0, 0.340]$	$15.62 + 23.35 I_T$; $I_T \in [0, 0.331]$	$15.62 + 23.83 I_T$; $I_T \in [0, 0.344]$
12	$15.67 + 20.73 I_T$; $I_T \in [0, 0.244]$	$15.67 + 23.52 I_T$; $I_T \in [0, 0.333]$	$15.67 + 23.55 I_T$; $I_T \in [0, 0.334]$	$15.67 + 23.49 I_T$; $I_T \in [0, 0.332]$
13	$15.51 + 21.23 I_T$; $I_T \in [0, 0.269]$	$15.51 + 23.82 I_T$; $I_T \in [0, 0.348]$	$15.51 + 23.31 I_T$; $I_T \in [0, 0.334]$	$15.51 + 23.71 I_T$; $I_T \in [0, 0.345]$
14	$15.97 + 21.20 I_T$; $I_T \in [0, 0.246]$	$15.97 + 23.66 I_T$; $I_T \in [0, 0.325]$	$15.97 + 22.75 I_T$; $I_T \in [0, 0.298]$	$15.97 + 23.71 I_T$; $I_T \in [0, 0.326]$
15	$15.50 + 21.11 I_T$; $I_T \in [0, 0.265]$	$15.50 + 23.51 I_T$; $I_T \in [0, 0.340]$	$15.50 + 23.01 I_T$; $I_T \in [0, 0.326]$	$15.50 + 23.85 I_T$; $I_T \in [0, 0.350]$

Table 2 shows that all the intervals are converted into fixed points. Variance from minimum to a maximum value is not defined by this approach. It reflects that classical approach is not reliable and efficient for decision making for a specific time. Table 7 shows that neutrosophic analysis of data is more reliable because of indeterminacy and it gives the detailed variance of dam temperature.

6. Graphical Demonstration of Analysis

Following is the graphical representation of classical analysis and neutrosophic analysis based on Table 2 and Table 7, respectively.

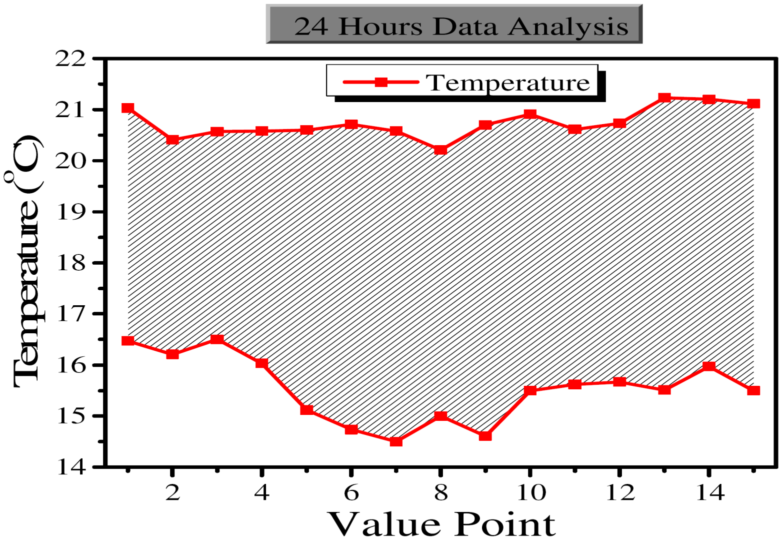

Figure 1. Graphical representation of 24 hours temperature analysis.

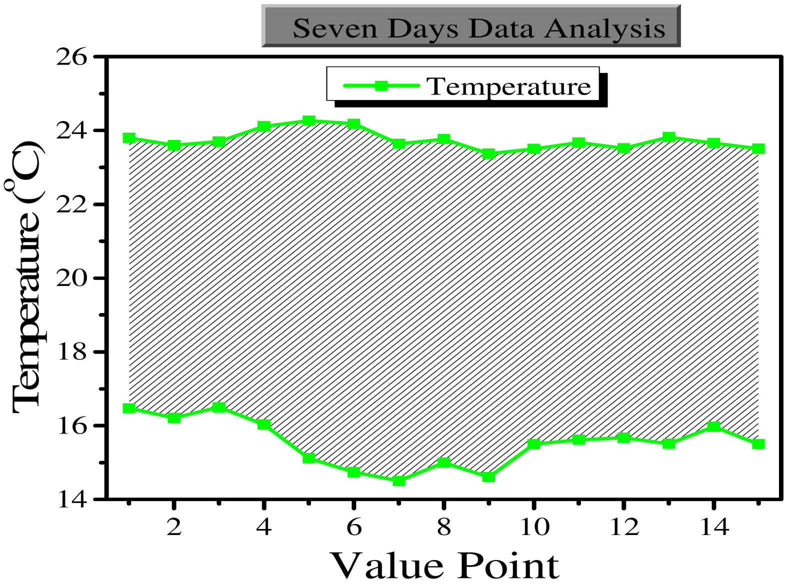

Figure 2. Graphical representation of seven days temperature analysis.

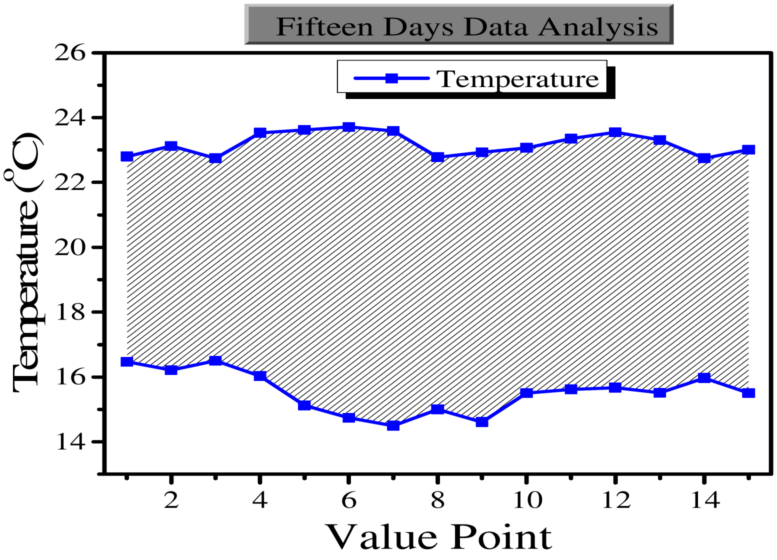

Figure 3. Graphical representation of fifteen days temperature analysis.

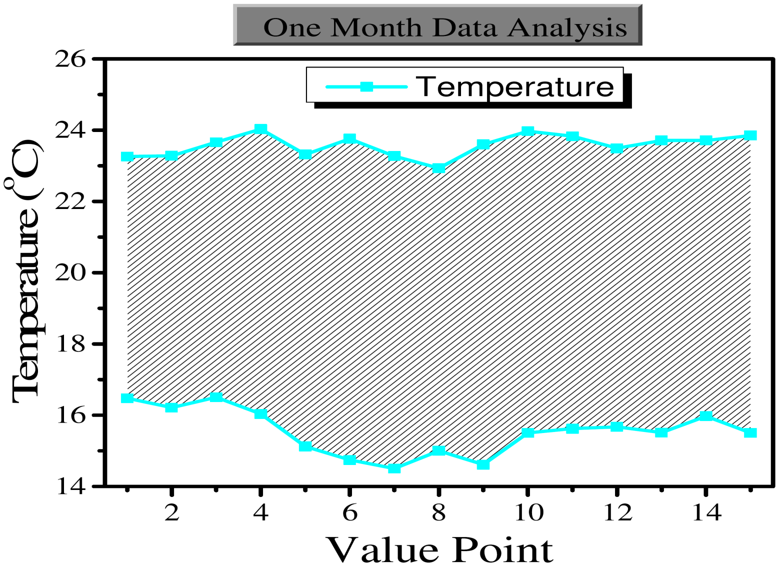

Figure 4. Graphical representation of one month temperature analysis.

Figures 1-4 show graphical comparison between classical and neutrosophic; in Figure 1, red lines indicate fix point classical analysis where black dotted lines are the neutrosophic indeterminacy interval values. Likewise same indeterminacy interval can be observed in Figures 2-4. We can observe that neutrosophic analysis graphs are more informative and provide flexible results. So we used the neutrosophic approach for the thermal analysis of dam.

7. Conclusion

The focus of this study was on thermal analysis of dam, for this purpose, we use temperature data of 24 hours, 7 days, 15 days and one month. In this study, we defined intervals using the dam body temperature measurement and then used neutrosophic approach for thermal analysis. To complete this study, applying the classical approach along with neutrosophic approach on measured temperature data, output graphs were drawn. To check the reliability, we compared both approaches. The classical approach provided fix point values where neutrosophic approach provided indeterminacy interval which was more informative. By comparing output graphs, it was observed that neutrosophic approach was more reliable and effective than the classical approach.

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